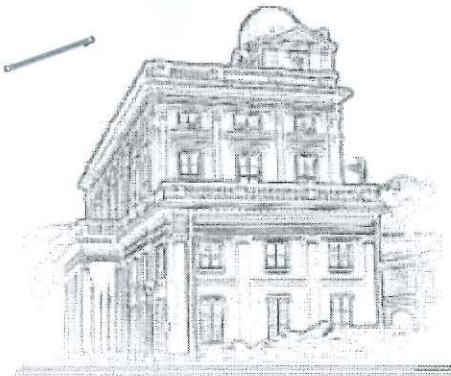

Astronomical Observatory
University of Warsaw

Al. Ujazdowskie 4, 00-478 Warszawa, Poland
tel: (48-22) 55-30-507 fax: (48-22) 629-49-67
www.astrouw.edu.pl

Prof. dr hab. Tomasz Bulik
Astronomical Observatory
University of Warsaw

Warsaw, July 25th 2018

Referee report on the doctoral thesis written by Roberta del Vecchio entitled "New study of afterglow lightcurves in gamma ray bursts".

The thesis written by Ms Vecchio contains results of analysis of several correlations in the lightcurves of gamma-ray bursts. The thesis comprises of seven chapters, and three appendixes. The first chapter is the introduction with the history of the studies of GRBs as well as supernovae. The second chapter is the description of the models of emission and central engines of GRBs. The following four chapters (3-6) are each based on published papers that include Ms. Vecchio as a co-author. According to the statements in the thesis her role was major in the paper presented in chapter five, an she is the lading author of the paper presented in chapter six. In chapter three she describes and analyzes several correlations between parameters of the prompt GRB emission. Chapter four contains discussion and analysis of the correlations between parameters that relate to the afterglows of GRBs. In chapter five the author discusses the selection effects that affects the correlations, while chapter contains an analysis of correlations in the decaying part of the afterglow lightcurves, following the plateau. Finally, in chapter seven a summary of the thesis is provided. Appendix A contains details of the fits of afterglow lightcurves performed by the author, appendix B is the description of the Swift mission, and appendix C contains the reprints of the papers that the thesis is based on.

The investigation of the correlation of various parameters describing the activity of GRBs has a long history and is an important subject. GRBs are the easiest probes of the high redshift Universe, so it is clear that finding some properties of these phenomena that can form standard candles out of them is a holy grail for cosmology. Additionally relations between parameters, like decay indices, variability, duration, and luminosity provides strong constraints on models of GRBs and may provide insight into the physics of their central engines. The goal is therefore very ambitious however the path to reach it is not easy. The relations obtained in the past by several authors are always strongly affected by selection effects. In the case of X and gamma-ray observations of highly variable objects like the GRBs these selection effects are not easy to determine and compensate for. Nevertheless, the subject of the thesis is an important problem in astrophysics and may lead to extremely valuable results in the future. For example one can use GRBs to investigate the cosmic evolution of dark energy or star formation at the early epochs. The results presented in the thesis are an important step on this path.

The main results obtained y the author are presented in chapters five and six. Chapter five is based n the paper "Selection effects in gamma-ray bursts correlations: consequences on the ratio between gamma-ray burst and star formation rates" by Dainotti, del Vechio, Shigehiro, and Capoziello (2015). The chapter is written in a quite comprehensive way, so that one needs to refer to the original paper in Appendix C to understand the main points. In this chapter I was surprised to see

that the detector selection effect is modeled using a function of the luminosity, i.e. assuming that all bursts above a certain luminosity are detectable regardless of their distance. I think that the proper parameter to use in the efficiency function would be the flux or fluence of a given burst. I would like the author of the thesis to explain this choice. In Figure 5.2.1 the caption says that the drawings show the rate density, however no units are provided for the quantity on the vertical axis. What are the units? In general I have the impression that this chapter ends too quickly. Only reading the paper it is based upon, includd in Appendix C, provides the true insight into the conclusions.

Chapter six is based on the publication "Study of GRB light curve decay in the afterglow phase" by del Vecchio, Dainotti, and Ostrowski (2016). The chapter is essentially a copy of the paper and this is fine since the author of the thesis was the leading author of the paper as well. The author discusses the correlation between the slope in the decaying part of the X-ray afterglow after the plateau phase with the luminosity at the end of the plateau phase. A quick look at Figure 6.4.1 shows that the correlation is weak. The existence of the correlation is then proven using the KS test performed by comparing several groups of bursts in different luminosity ranges. Why has the author used the KS test and not any more powerful statistical tool? Finally the author only touches on the very interesting subject of the GRB standardization. I guess that this could be the clue of the thesis as this may lead to luminosity estimates and construction of Hubble diagram. This chapter seems to have quite a potential for growth yet it ends so quickly.

I have several minor corrections to the statements in the thesis, especially in the Introduction. Already at the very beginning of the thesis the author claims that the original paper by Klebesadel, Strong and Olson (1973) has excluded the galactic origin of GRBs. In reality one had to wait until 1993 for BATSE to see the isotropic distribution and until 1997 for the Bepppo SAX discovery o X-ray afterglows to exclude the galactic origin of GRBs. How could Mazets (1981) find the bimodal distribution of duration in the BATSE data, when BATSE was launched in early 90's ? The compactness problem (see sec 2.1) was initially realized by Ruderman (1975) and Schmidt(1978), while Piran (1999) worked on it much later. I can go on with the list of inaccurate citations for a long time – there is quite a number of such cases in the paper. Additionally, I think that the description of the photospheric model on page 38 is not clear enough and should be expanded in more detail. Some figures have microscopic labels and axis descriptions – I really beg the author to have mercy on the eyes of the readers!

In summary, the author has prepared a comprehensive review of the properties of various correlations between the parameters in the afterglows. There is a very complete set of references. The main part of the thesis – related to the analysis of the luminosity – slope in the afterglow phase correlation is shown in Chapter six, additionally the author discusses the selection effects in Chapter 5. The results of both Chapters five and six have been published in The Astrophysical Journal and constitute solutions to important astrophysical problems. Thus I am convinced that the thesis fulfills the legal requirements for the doctorate degree and I recommend that the authors is allowed to proceed to the thesis defense.

Przedstawiona rozprawa spełnia ustawowe wymagania stawiane pracom doktorskim i wnoszę dopuszczenie do dalszych etapów przewodu doktorskiego.